

Fig. 1

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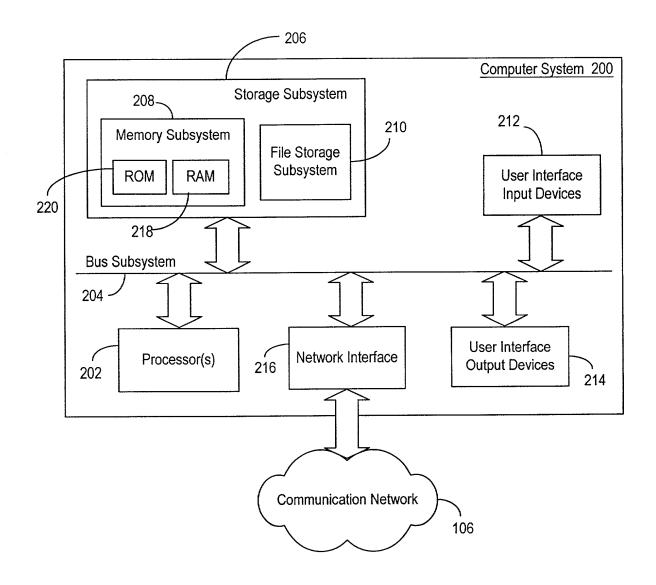


Fig. 2



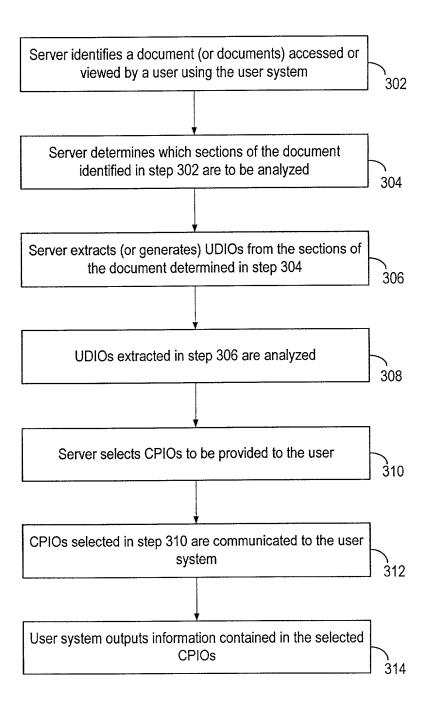


Fig. 3



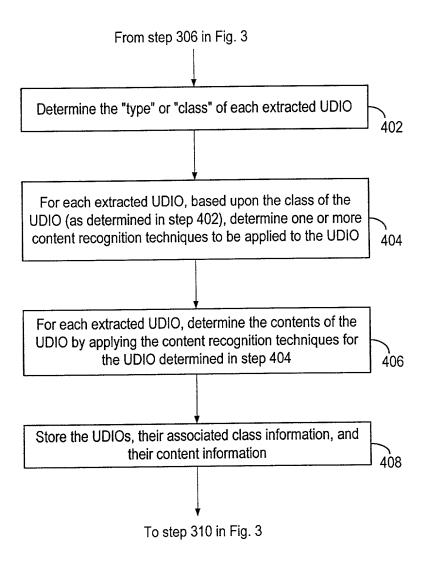


Fig. 4

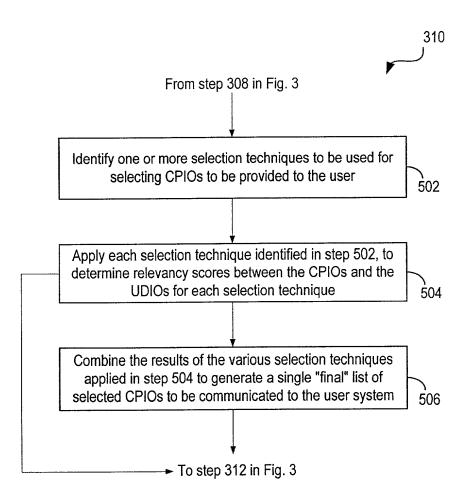


Fig. 5

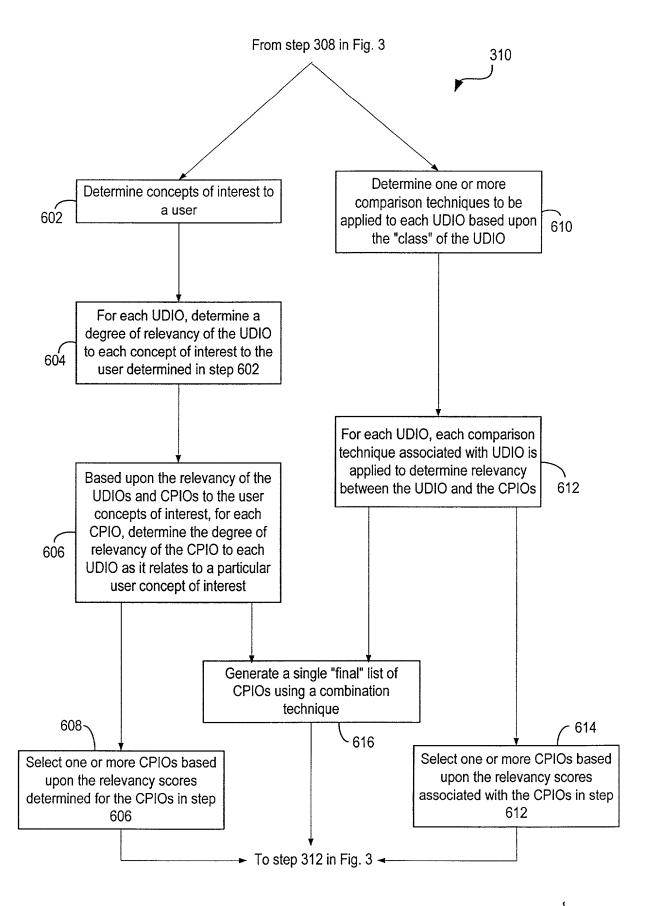


Fig. 6

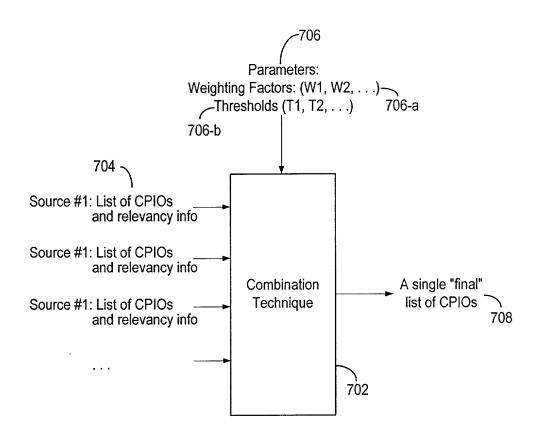


Fig. 7

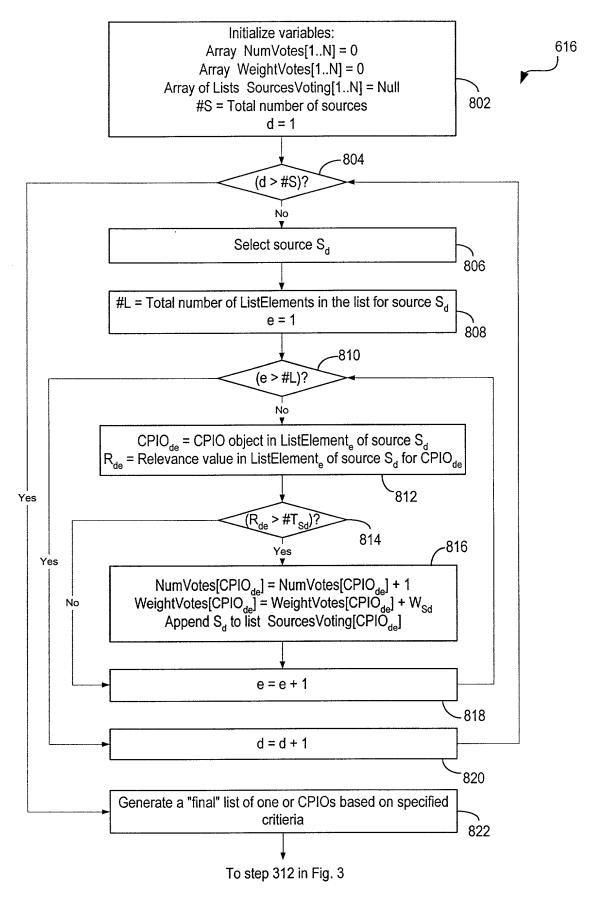


Fig. 8

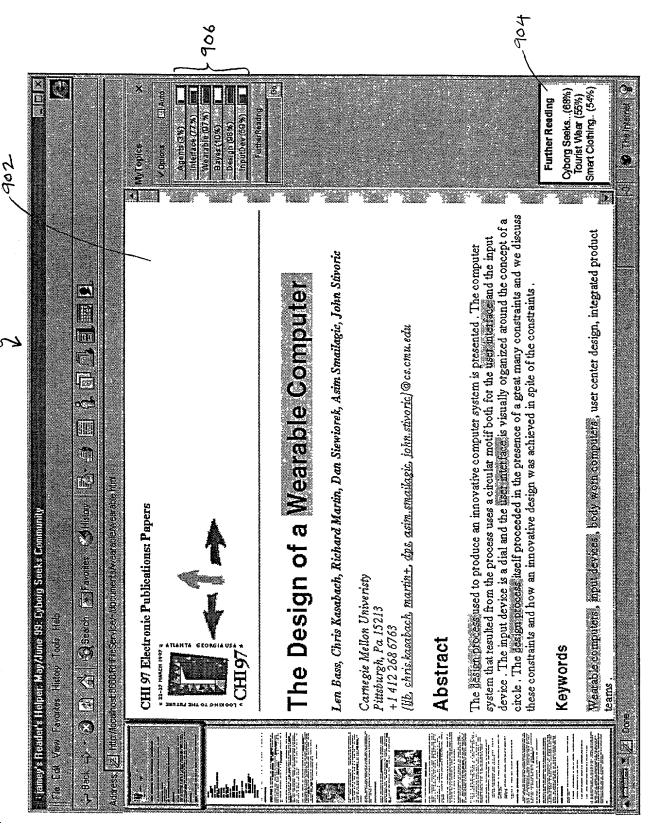
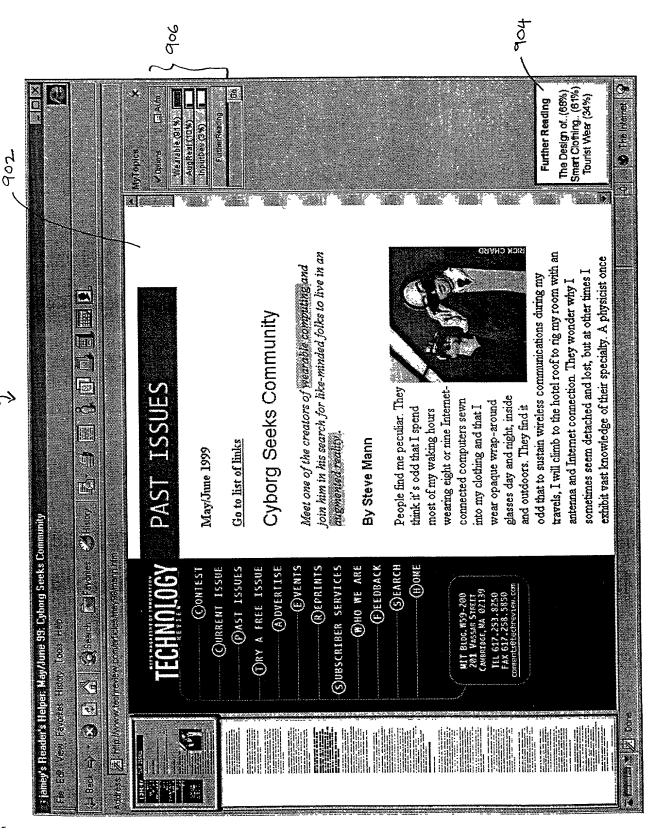


Fig. 9A







Digital Manipulatives: New Toys to Think With

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Abstract

manipulatives" -- computationally-enhanced versions of traditional children's toys. These new manipulatives enable children to explore a new set of concepts (in particular, "systems concepts" such as feedback and emergence) that have previously been considered "too advanced" for children to learn. In this paper, we discuss four of our digital manipulatives -- computationally-In many educational settings, manipulative materials (such as Cusenaire Rods and Pattern Blocks) play an important role in children's learning, enabling children to explore mathematical and scientific concepts (such as number and shape) through direct manipulation of physical objects. Our group at the MIT Media Lab has developed a new generation of "digital augmented versions of blocks, beads, balls, and badges.

Introduction

Walk into any kindergarten, and you are likely to see a diverse collection of "manipulative materials." You might see a set of Cuisenaire Rods: brightly colored wooden rods of varying lengths. The colors and lengths of the rods are carefully chosen to engage children in explorations of arithmetic concepts and relationships. Children discover that each brown rod is the same length as two purples -- or four reds. On the next table, you might see a set of Pattern Blocks. Children can use these polygon-shaped tiles to create mosaic-like patterns -- and, in the process, learn important geometric concepts.

97

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explore with these traditional manipulative materials. In particular, traditional manipulatives generally do not help children learn concepts such as number, size, and shape. But there are many important concepts that are very difficult (if not impossible) to As children build and experiment with these manipulative materials, they develop richer ways of thinking about mathematical